RADIAL GROWTH OF BEECH AND SOIL MOISTURE IN A CENTRAL OHIO FOREST DURING THE GROWING SEASON OF 1952.[1]

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In recent years there has been considerable interest and research on micro-environments in central Ohio (Wolfe *et al.*, 1949). Christy (1952) and DeSelm (1952) measured the temperatures and carbon dioxide gradients respectively in a beech-maple forest. During 1952 Gilbert (1953 and unpublished data) measured the rainfall interception and the soil moisture at Blacklick Woods, one of the forest parks near Columbus, Ohio. The author believed that additional measurements on the growth of trees during the same period might help to relate some of these factors to the development of the forest community.

Beech, *Fagus grandifolia* Ehrh., was chosen as the study tree, for it is a dominant member of the beech-maple association and extends into the adjacent swamp forest to the edges of the depressions which in spring are woodland pools.

REVIEW OF LITERATURE

Interest in tree growth is by no means a recent development. According to Glock (1941) the literature of the nineteenth century contains many references to various aspects of tree growth. The earliest studies dealt mainly with the nature and significance of growth rings. Later interest also included meristematic and cambial growth and their relationship to heredity and environment. Friesner (1943) discusses some of the pertinent literature on tree growth under three subdivisions: elongation, seasonal diameter growth, and annual ring studies of past years.

There is considerable literature dealing with the interrelationships between tree growth and environment. Adams (1935) reviews much of this and discusses many of the factors. He points out that variations in radial growth of trees may be due to hereditary differences, physiological differences due to conditions and age of the individual, and differences in the environment.

Several other workers, among whom are Glock (1941) and Robbins (1921), have also recognized differences in growth due to heredity and physiological conditions. MacDougal (1924) has demonstrated from growth studies that the seasonal growth period of an individual tree varies with age as well as with different physiological conditions. He reports that the growth period in *Pinus radiata* was longest in young trees while wider differences in growth were exhibited by older trees.

Others, Lyon (1940), Glock (1950), and Lodewick (1930), report that many of these variations in growth of individual trees are overshadowed by environmental influences in a particular site. Schulman (1941) states that the relative importance of any one of the environmental factors operating on tree growth varies from region to region and site to site.

Friesner (1941, 1942), Lodewick (1928), and MacDougal (1936) have compared seasonal climatic conditions to cambial activity and radial increase in growth. The varying effects of environmental factors throughout the season are mentioned by Lundengardh (1931). In temperate latitudes he divides the year into four ecological climatic periods; (1) the growth period of spring, (2) the assimilation period including summer and early autumn, (3) the fruit formation period, and (4) the winter of after-ripening period. He states that growth is primarily determined by the climate of spring and photosynthesis by the climate of mid-summer and autumn.

[1]Department publication number 565.

MacDougal (1938) shows that in general the time of initiation of cambial growth in *Pinus radiata* depends largely upon temperature, and time of cessation varies from year to year depending largely upon time of exhaustion of the water supply. Friesner (1941) in his work on beech states, "In the earlier part of the season, when water supply is most likely to be adequate, temperature is more likely to become the limiting factor, whereas in the later part of the season, when temperature is adequate, available water and evaporation become the limiting factors. . . . As temperature increases the demand for water to supply evaporation losses increases also and thus makes available water a still more potent limiting factor."

Reineke (1932) introduced a dial-gauge dendrometer for precise measurement of radial growth, and more recently an improved dendrometer was described by Daubenmire (1945) and is now widely used.

LOCATION AND DESCRIPTION OF THE STUDY AREA

The forest in which this study was conducted is a relatively undisturbed area called Blacklick Woods and is located 10 miles east of Columbus, Ohio, and a mile SSW of Reynoldsburg, Ohio. It is now one of the several Columbus Metropolitan Parks. It lies in the extreme northwest corner of Fairfield County, its western border lying on the Franklin-Fairfield County line and its northern part extending into Franklin County. It is located at about 82° 49′ west latitude and 39° 56′ north longitude.

The area is on the gently undulating late Wisconsin till plain, with elevations varying from 870 to 895 ft. Three soil types of the Alexandria catena are present. These are Marengo silty clay loam in the depressions where water accumulates nearly every spring, Bennington silt loam in the surrounding level to gently sloping areas, and Cardington silt loam on the crests of the gentle rises. The differences in relief between these soil types may be only a few feet, yet the plant communities at the two extremes are distinctly different.

The dominant species occurring in the depressions are: *Ulmus rubra*,[2] *Ulmus americana*, *Fraxinus americana*, *Acer rubrum* and *Acer saccharinum*. The dominant species on the higher sites are: *Fagus grandifolia*, *Acer saccharum*, *Ulmus rubra* and *Ulmus americana*. Less prominent species in the study area are: *Tilia americana*, *Carya ovata*, *Carya cardiformis*, *Juglans nigra*, *Prunus serotina*, *Nyssa sylvatica*, *Quercus bicolor*, *Quercus palustris*, *Acer negundo*, *Ostrya virginiana*, *Asimina triloba*, and *Crataegus* spp. A dense understory of spice bush, *Lindera benzoin*, characterizes both communities except in the areas of the woodland pools and in the most mature and well drained sites.

Beech occurs in different proportions between the depressions and the highest sites in the gradiation from swamp forest (Sampson 1930) to beech-maple. An analysis of this transition in the forest studied was made by sampling areas of similar relief by means of walking transects through each area. Care was taken to record every tree within arm's length and over 5 ft. high, and not to include any one individual more than once. All trees were tallied to the nearest odd inch dbh. The sampling areas occupy roughly three sites: near depressions (1.5 to 3.0 ft. higher than the bottom of neighboring depressions), on gentle rises (3 or more feet above the depressions), and on the highest sites (on top of knolls or along crests of rises). The total relief in the sampling area was no more than seven feet. Table 1 illustrates some of the differences between these communities.

Near the depressions elm is dominant constituting 25 percent of the community and 46 percent of the basal area with beech the next important species. However, the beeches are often small trees which are gnarled and decayed in the center. On the gentle rises elm becomes secondary to beech which constitutes 38 percent of the community and 76 percent of the basal area in this site. On the highest

[2]The nomenclature is that of *Gray's Manual of Botany* (Fernald 1950).

sites beech becomes less important as sugar maple increases in number and size in the beech-maple association.

METHODS

During the spring of 1952 three beech trees were selected from these three different habitats in the forest. Radial increase of the trunks was measured by the dendrometer method described by Daubenmire (1945) and discussed by Brown *et al.* (1947). Three 2-inch screws were inserted 1.5 in. into the tree about 5 ft. above the ground. By placing a dendrometer upon these, the distance from the heads of the screws to the bark could be measured. A small area of the bark was covered with shellac where the spindle of the instrument touched the tree. Measurements were made on three radii in each tree at intervals of several days from April 17 to November 15, between 12:00 noon and 4:00 pm. EST. Soil moisture readings were taken by Gilbert (unpublished data) near the three sites

TABLE 1

Vegetational analysis of several sites in Blacklick Woods

Species	Near Depressions		On Gentle Rises		On Highest Sites	
	Trees over five feet high	Basal area	Trees over five feet high	Basal area	Trees over five feet high	Basal area
Acer saccharum	5%	—	27%	5%	26%	22%
Fagus grandifolia	14%	31%	38%	76%	23%	62%
Ulmus rubra / *Ulmus americana*	25%	46%	14%	19%	18%	16%
Acer rubrum / *Acer saccharinum*	12%	9%	0	0	2%	—
Fraxinus americana	10%	4%	2%	—	2%	—
Other species	34%	10%	19%	—	19%	—

TABLE 2

Soil moisture constants for the Colman units in three sites at Blacklick Woods (percent moisture)

	Depth of Unit	Horizon	Moist. Equiv.	15 atm.	P.W.P.	Lowest Record
Highest Site	7.0 inches	A_2	29.5	6.6	9.4	6.5
	22.5 inches	B_{22}	30.0	15.3	15.6	15.5
Gentle Rise	5.5 inches	A_2	29.5	6.6	9.4	15.5
	15.5 inches	B_{21}	32.0	17.3	17.5	20.5
In Depression	6.0 inches	A_1	44.5	19.5	22.8	26.5
	19.0 inches	Bg_2	45.0	16.0	17.5	26.5

throughout the period at several depths by means of the Colman fiberglas soil moisture units. Moisture equivalents were ascertained by centrifuging the sample at one thousand times gravity for 30 minutes. The percent moisture at 15 atmospheres was determined by the pressure membrane method. The permanent wilting percent (P.W.P.) was ascertained by allowing six-inch oat plants growing on undisturbed cores to wilt in controlled light and temperature rooms (table 2).

DESCRIPTION OF SITES

The tree near the depression is 100 ft. from the center of the depression and 1.5 ft. higher. All adjacent canopy trees are approximately 20 to 25 ft. distant and are elm (*U. americana* and *U. rubra*) and ash (*F. americanum*) except for one 20-inch beech on the up-slope side. The understory consists of scattered spice bush, herbaceous plants and tree seedlings. The soil at the base of the tree is Bennington silt loam towards the rise and Marengo silty clay loam towards the depression.

The tree on the gentle rise is 250 ft. up-slope from the tree near the depression, and it's base is 4.5 ft. higher. The slope rises about one foot beyond this tree leveling off into a gently undulating area of beech and elm. The tree is younger than the other two and had recently entered the canopy. It borders an opening in the canopy to the northeast, and within 15 ft. on this side are four other beeches 10, 9, 9, and 5 in. dbh as well as a dense understory of spice bush. But on the opposite side of the tree the forest floor is open with little or no spice bush. Neighboring trees on this side are mature canopy individuals of ash, beech, and sugar maple (*A. saccharum*), all further than 15 ft. from the tree.

The tree on the highest site is near the crest of a small knoll which rises on the average of three feet in 100 from the more level surrounding swamp forest. The area adjacent to the study tree is occupied by four large canopy trees of beech ranging from 18 to 26 in. dbh approximately 20 feet distant. About 30 ft. southeast there is a small area of open canopy and elm and spice bush understory. However, within a 25 ft. radius the forest floor is relatively open.

Unfortunately the soil moisture units in the depression were placed in a site 6 in. lower and 150 ft. from the tree studied. However, they were on the opposite side of the depression and not far from identical sites which lacked a suitable beech tree. Adjacent trees to the units were all elm, ash, and red maple (*A. rubrum*). The units were buried in the A and B horizon of Marengo silty clay loam (table 2) which is more poorly drained and has more organic matter in the A horizon than the neighboring Bennington soil. The moisture units on the gentle rise were 15 ft. west of the tree and in the area of little understory. The units were buried in the A and B horizon of Cardington silt loam. The units in the highest site were 20 ft. from the study tree and also within the area of little understory. They too were buried in the A and B horizon of Cardington silt loam.

The relationship between soil moisture, understory, and "competition" was studied by Korstian and Coile (1938). By trenching experiments they demonstrated that:

> "Survival of plants under natural forest canopies is dependent upon a complex of factors. It varies not only with climate and altitude, but very markedly with soil moisture, soil temperature, soil nutrients, light intensity, and other factors as well. Light intensity is usually subordinate in importance."
>
> "Marked changes occurred in vegetation of the trenched plots after trenching . . . Trenching was followed by increases in number of individuals, number of species, and general luxuriance of vegetation."
>
> "It is believed that the study clearly demonstrates that competition between individuals of the forest vegetation for soil moisture is a highly significant factor in the growth, development, and reproduction of forests in the Piedmont plateau."

The same phenomenon appears to exist in the study area at Blacklick Woods. Recognition of soil moisture as a primary effective variable makes the distribution of the spice bush understory intelligible. On the highest sites, where the canopy is closed and the soil moderately well drained, the understory is sparce. However, in the less well drained sites where there is lateral movement of soil water from the adjacent higher sites, and in the disturbed well drained sites where "competition" is not as great, spice bush and other understory species are abundant. But in the largest depressions where water stands until early summer the understory is again absent.

An estimate of the "competition" and moisture relationships in each site can be then be made as follows: The tree near the depression and the soil moisture units represent a mature swamp forest site where "competition" is maximum for that particular association. The units were in a slightly more moist site than the tree, but the moisture regimens probably did not differ greatly. The tree on the gentle rise bordered between a relatively mature beech-maple association and a large opening in the canopy. As a result, toward the opening "competition" as discussed by Korstian and Coile (1938) was lower and the understory abundant, while on the opposite side, "competition" was greater with little understory.

Since the moisture units were placed in this latter area, the readings in all probability represent a slightly dryer regimen than that for the total root system of the tree. If there is no future disturbance, this area will probably return to mature beech-maple.

The tree on the highest site was not only on a slightly better drained site but in a more mature community than the second tree, and hence "competition" was greater. As a result, the spice bush understory was lacking. Here the moisture readings should represent the approximate regimen for the study tree.

TABLE 3

Weather data for January through September, 1952, compared to means for 1900 to 1951

Recording Period	1952 Mean Temperature Degrees F. Columbus	1900–1951 Mean Temperature Degrees F.	1952 Mean Temperature at Blacklick Woods	1952 Precipitation in Columbus	1900–1951 Mean Precipitation	1952 Precipitation at Blacklick Woods
Jan.-Apr.	—	—	—	16.75 in	11.50 in	—
May	62.3°	62.2°	59.9°	3.04 in	3.20 in	3.02 in
June	77.0°	71.2°	73.5°	3.56 in	3.58 in	2.65 in
July	78.5°	75.4°	76.7°	0.96 in	3.46 in	1.59 in
August	73.9°	73.5°	73.4°	2.50 in	3.06 in	2.53 in
September	67.0°	67.2°	66.6°	1.84 in	2.49 in	2.80 in

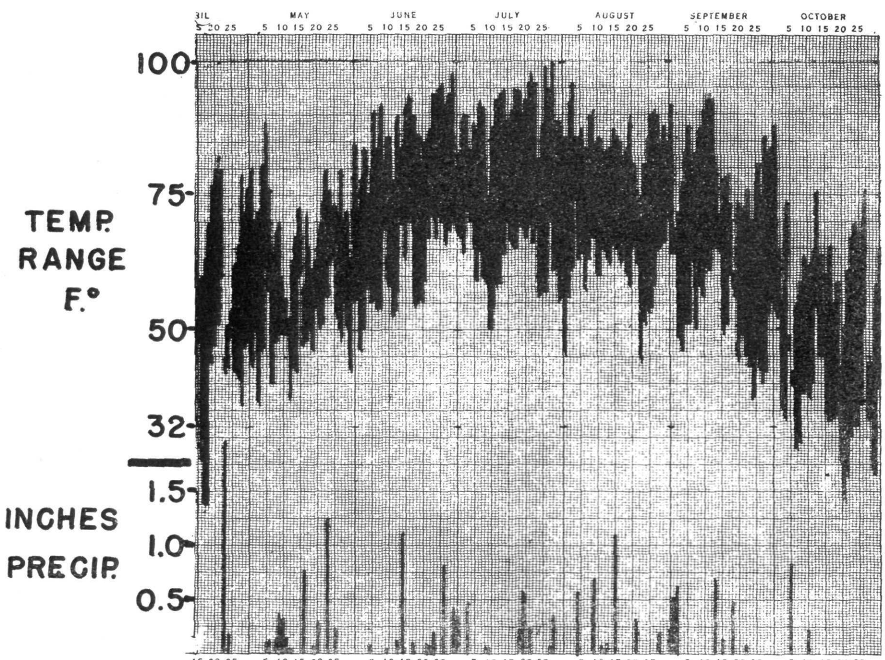

FIGURE 1. Daily Temperature Range and Precipitation During the Growing Season of 1952.

WEATHER BUREAU AND CLIMATIC DATA

Precipitation and temperature means for January through September, 1952, as calculated for the city of Columbus (U. S. Dept. of Agriculture, 1935 and U. S. Weather Bureau, 1931–1952) and at Blacklick (Gilbert 1953 and unpublished data) are given in table 3. The daily temperature range and precipitation for April 15-

October 1952 are graphed in figure 1. Unusually high precipitation during January through April resulted in abundant moisture during the spring. Assuming that the temperatures in the woods were proportionally above the average as were the city temperatures, and that the precipitation means were the same, we can conclude that the precipitation in June and July was below average and the temperature much above average in the forest. The seasonal conditions can be summarized as abundant or above average moisture in the early spring followed by below average moisture or drought conditions with high temperatures in July. This caused the spring water table to be unusually high and the July soil moisture to be unusually low.

TABLE 4

Radial increase of three beech trees from April 16 to November 1, 1952

Location	dbh	Radii	Compass Direction of Radius	Seasonal Increase in Radius
Highest Site	20.1 in	3	70°	.060 in
			330°	.047 in
			200°	.045 in
On Gentle Rise	14.1 in	3	200°	.115 in
			20°	.100 in
			330°	.083 in
Near Depression	19.6 in	3	60°	.034 in
			220°	.030 in
			310°	.025 in

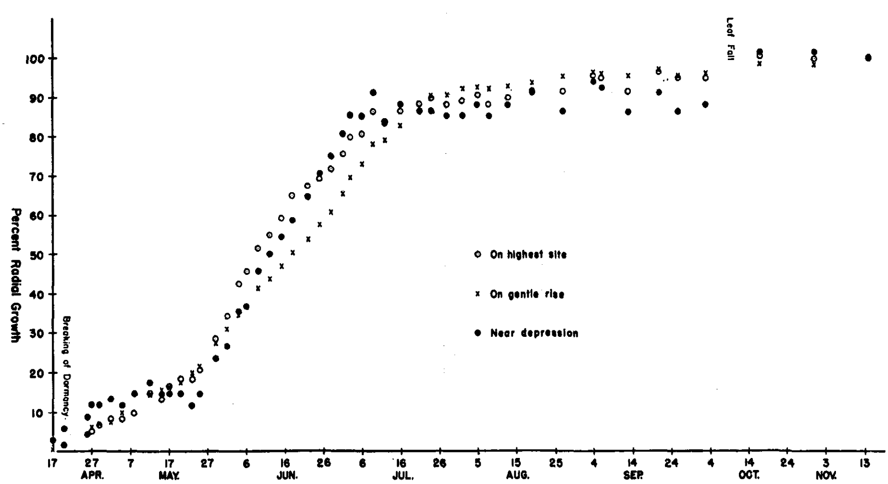

FIGURE 2. Per cent of radial growth in three beech trees on several sites during the growing season of 1952.

RESULTS

At the end of the season the growth curves for the trees were plotted and compared. In table 4 the dbh of the three trees and the radial increases for each radius is given. Even though the total increments were variable, the growth curves were proportional, so the radius with the greatest increase was chosen and the data converted to percent of total growth and plotted in figure 2. From the curves it is apparent that the three trees resembled those described for beech by Daubenmire and Deters (1947), Friesner (1941), and Jackson (1952). The breaking of dormancy occurred approximately April 20 and was subsequently followed by radial changes. However, a continuous regular increase did not start until between May 17 to 27 which marked the beginning of the grand period of growth (Friesner 1943). The period of maximum growth continued through June and the first week in July. This was followed by cessation of growth which was not completed in one of the trees until early September.

Although some fluctuations in tree size occurred in late April and early May, the period of greatest fluctuation began in July and lasted until leaf-fall in October. After leaf-fall all the radii increased from .002 to .005 in. and remained at a relatively constant value until the end of the recording period. Since the measurements were made in the afternoon, when the water deficit due to transpiration was greatest (MacDougal 1936) it is not startling to find sizeable fluctuations in the radius. It appears (figure 2) that the fluctuations in the tree near the depression were larger than those in the other two trees. However, this is only the result of converting the data to percent growth. The tree near the depression grew the least and as a result the fluctuations became a larger percent of the total growth than in the other two trees.

TABLE 5

Deviations in three beech trees from the 7:00 AM readings during July 12, 1952
(in thousandths of inches)

Location and Site	Compass Direction of Radius	Approximate Time of Record					
		7:00 am	10:30 am	1:15 pm	2:45 pm	4:25 pm	6:30 pm
Highest Site	70°	0.0	−1.5	−2.0	−2.5	−2.5	−2.0
	330°	0.0	−1.5	−2.5	−3.5	−4.0	−3.5
	200°	0.0	−1.0	−2.5	−4.0	−3.5	−3.0
On Gentle Rise	200°	0.0	−1.5	−2.0	−2.5	−2.5	−2.0
	20°	0.0	−2.0	−2.0	−3.0	−3.0	−2.0
	330°	0.0	−2.0	−2.5	−3.0	−3.0	−2.5
Near Depression	60°	0.0	−1.5	−2.5	−3.0	−2.5	−2.5
	220°	0.0	−1.0	−2.0	−2.5	−2.0	−2.0
	310°	0.0	−1.0	−1.5	−2.0	−1.5	−1.5

As a check on the actual daily fluctuations that occur among the trees, measurements were made on all radii at several hour intervals during July 12, 1952. The day was clear with low humidity and maximum and minimum temperatures of 93° and 58° F. The relative changes in radius are included in table 5. The radial decrease is strikingly uniform among all three trees. However, the greatest shrinkage did occur in the tree on the highest site where the soil moisture at 7 and 22 in. was lowest.

It is apparent from figure 2 that the three curves show some subtle differences in shape due to differences in growth rate. For further analysis the data are graphed in figure 3 as total growth or increase in size per 5-day periods from April 25 to September 17. Below these are the corresponding graphs of the average soil moisture percentage for 5-day periods in the A and B horizons of each site. The P.W.P. is the permanent wilting percentage and the hatched area represents the percent of available water. On inspection of the top graphs the differences in the three growth curves are apparent. The tree on the gentle rise had the maximum increase in early July after which there was a gradual reduction in growth rate with only a little further increase after the first of August. However, the tree on the highest site had its maximum increase a month earlier in June, after which there was a gradual decrease in rate until July 10. No further increases occurred until August. The tree near the depression also had a small peak in growth during the same period in June followed by 30 days of relatively uniform growth. In early July there was an abrupt cessation of growth with no further increase recorded until August.

The soil moisture in the sites near these trees also differed throughout the growing season. The soil moisture on the gentle rise decreased gradually throughout the growing season in both the A and B horizon but never reached the wilting percentage. In this site it appears that moisture was ample for growth, and the tree exhibited a similar growth pattern to the beech reported by Daubenmire and Deters (1947) which grew in an arboretum in Moscow, Idaho.

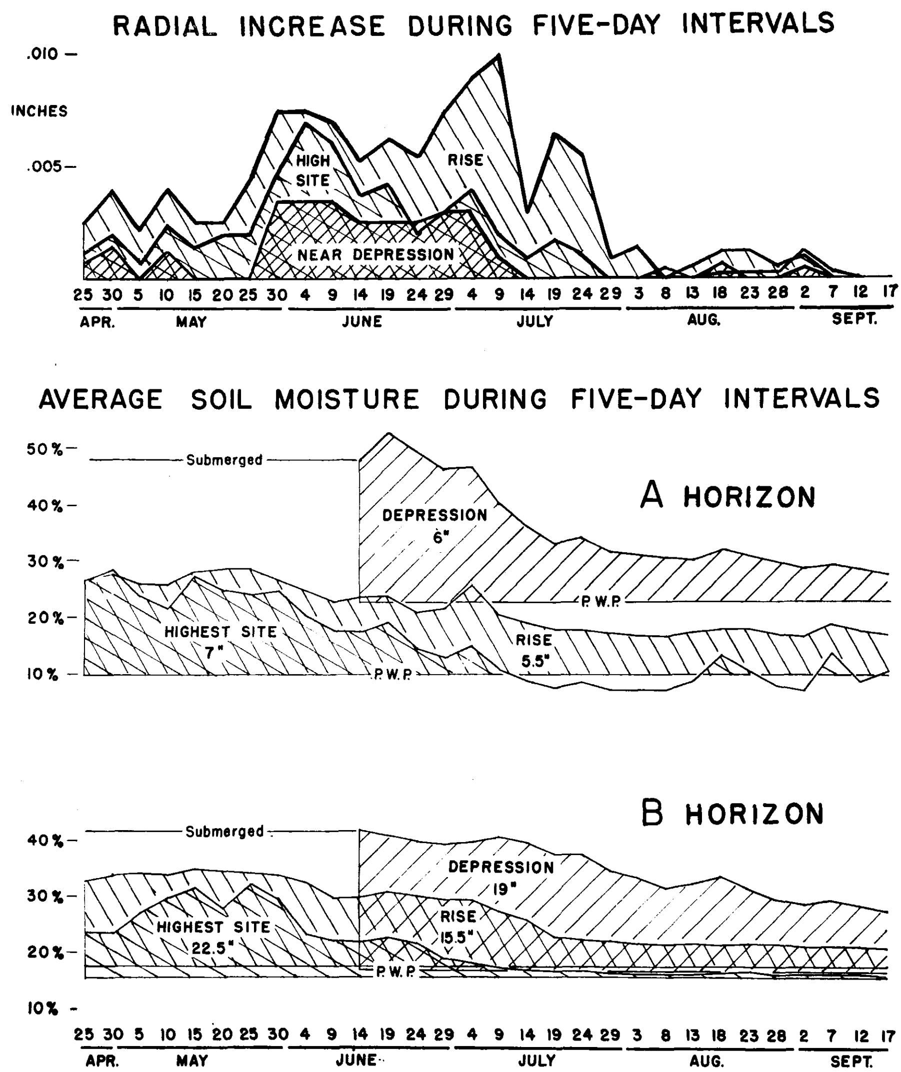

FIGURE 3. Radial growth and soil moisture at three sites for five-day periods during the growing season of 1952.

The soil moisture on the highest site decreased more rapidly throughout the season, passing below the wilting percentage in the middle of July in the A horizon and approaching this value in the B horizon. It appears that the moisture in this site gradually became increasingly limiting to growth, causing a correspondingly gradual decrease in growth rate which practically stopped in July.

Soil moisture in the depression demonstrates a still different regimen. There was water in the depression until mid-June and the moisture units were submerged. By early July the soil moisture in the A horizon began to decrease rapidly. The soil moisture regimen for the tree near the depression was probably not identical, but because of its proximity to the depression, it can be inferred that it was a correspondingly wet early season followed by a similar rapid reduction in soil moisture in early July. It was at this time that radial increase abruptly stopped.

DISCUSSION

Friesner (1943) points out that "Hourly variations in diameter are recorded by the dendrograph during some parts of the vegetative season for all species studied. These daily reversible variations are entirely due to turgidity changes and set in whenever the transpiration loss exceeds the ability of the absorbing and conducting organs to supply water."

MacDougal (1938) has demonstrated a very close relation between diameter of trees and available moisture in his irrigation experiments.

Therefore, the most likely cause of the greater fluctuations (fig. 2 and 3, table 5) in the trees during the latter part of the season of 1952 is low soil moisture and high temperature and subsequently high evaporation. This is borne out by the fact that the tree on the highest site which had the least available moisture showed the greatest shrinkage (table 5).

Several workers have described a limiting effect of soil moisture on radial growth in the latter part of the season. Cantlon (1953) demonstrated that oaks on a south facing slope had a more marked "response" to rainless periods and had less radial growth in the latter part of the season than the oaks on the north facing slope. Reimer (1952) reports similar results with sugar maple. He states that the growth curves for sugar maples at the edge diverge from those for the trees in the center of the woodlot in the latter part of the season. The soil moisture regimens for these trees also show a similar divergence. He concluded that soil moisture was not critical at any time within the woodlot but dropped to a critical level during the last few weeks of the enlargement period for the trees near the south and west edges.

Friesner (1943) describes the growth curve for beech as always appearing ". . . to show a grand-period type of behavior. Environmental conditions, especially the temperature-available moisture-transpiration complex, plays a prominent part in the time of initiation, the amplitude of the curve, and the time of its cessation . . .". He (1941) compares the growth measurements of beech by Gericke in Baltimore, Maryland to his measurements:

> "In both studies growth changes were first noted coincident with the time of full expansion of the leaves, which in both instances was the middle of May. In Baltimore tree growth continued until June 5 and showed intermittent growth, correlated with rains, until the latter part of September. In the Indianapolis trees diametral increase reached its maximum rate by the middle of July. From the last date until the end of the calender year, decreases and increases alternated in correlation with rainless and rainy periods."

He further compares his growth measurements on beech in 1940 and 1941. In discussing the growth cessation he states "Growth reached a zero point in 1940 during the week ending July 15 and in 1941 during the week ending June 16. The abrupt ending of radial changes in 1941 is correlated with drought conditions." Both he (1941) and MacDougal (1938) consider the lack of soil moisture the primary factor limiting growth in the later part of the season.

Several workers (Kramer 1949) have shown that trees in poorly drained sites have shallower root systems than those on better drained sites. The author has dug pits into the different soil types in the woods and has noted a similar relationship there. In addition the roots are also more concentrated in the A horizon of the poorly drained soils.

It would therefore be reasonable to expect the results obtained in this study. The trees near depressions which have shallow root systems would show a very marked reduction in growth in the middle of a season with high spring and low summer precipitation and soil moisture. With the disappearance of water from the depressions, the soil moisture in the A horizon where the roots are most concentrated would rapidly decrease. Since the largest part of the tree roots are confined to this layer, there would be a rapid decrease in the water available to the tree and subsequently a rapid cessation of growth.

But the trees in the best drained sites with deep and less concentrated root distributions would show a more gradual reduction in growth rate as the available water is slowly reduced. Because of their better drainage, the growth cessation in these trees would begin much earlier.

The trees in less well drained sites and/or in areas of less "competition" would have a correspondingly longer growth period than either of the extreme sites. Soil moisture would neither decrease fast enough or be close enough to the wilting percent to become limiting to growth.

Two neighboring trees to the highest site which were also measured had similar but less distinct trends as the tree previously described. Another young tree near the one on the gentle rise had a similar regimen to it. Several other trees not quite as near to the depression as the tree used in this study were also measured with varying results. Some had curves similar to the tree and others appeared more like the tree on the rise. However, none of the trees near the depression had regimens like the tree on the highest site.

This variation from tree to tree is not in disagreement with the preceeding results. As was pointed out, soil moisture is affected not only by the degree of drainage and soil type but also by the degree of "competition" which is in turn dependent upon the successional relationship. Therefore, two trees on the same soil type but one in a disturbed area and the other in a mature area would have different moisture relations and consequently different growth regimens. This is quite apparent when one tries to compare the growth of trees on different sites where soil moisture has not been measured. The lack of distinct environmental and successional differences makes it difficult to group such trees into categories for statistical treatment. For this reason the author confined his discussion mainly to the three trees nearest the moisture units.

RADIAL INCREASE AND INCREMENT GROWTH

When these data are applied to the production of wood in the tree, the question arises as to how closely radial growth can be correlated with the formation of annual rings. To check this relationship, borings were made with a Swedish increment borer during January, 1953 at the same radii on which radial increases for 1952 had been measured. The cores were mounted on a grooved board and sanded with a high speed sander until the growth rings could be clearly seen. The increment growth at each radius for 1952 was measured to .001 in., and these data are compared to the dendrometer measurements in table 6.

It is apparent from the table that increment growth is directly proportional to radial growth. However, the tree with the greatest seasonal growth had the greatest "increment/radial growth" while the tree with the least had the smallest. It appears that for beech the increment of xylem formation is proportional to radial growth, at least in total amount. The differences in total radial growth appear to be due more to differences in thickness of xylem than of any other tissue of the trunk.

SUMMARY

The radial increase of three canopy beech trees was measured throughout the growing season of 1952 by means of the dial-gauge dendrometer. Soil moisture

was measured with Colman fiberglas soil moisture units in the A and B horizons in near-by sites.

One tree was near a depression in a mature swamp forest community. The second tree, which was younger, was on a gentle rise and bordered an opening in the canopy. The third was in a mature beech-maple community on a slightly better drained site than the second.

The precipitation during the year was above average from January through April and below average from June through August. The average temperatures in June and July were 6° and 3° F above average.

Fluctuations appeared in the measurements during mid-summer when drought conditions were most severe.

TABLE 6

Comparison of increment growth to radial growth of three beech trees during 1952

Location	Compass Direction of Radius	Increment Growth (in thousandths of inches)	Radial Growth (in thousandths of inches)	*Increment* Radial Growth
Highest Site	70°	47	60	.78
	330°	38	47	.81
	200°	30	45	.67
Average		38	51	.75
On Gentle Rise	200°	109	115	.95
	20°	73	100	.73
	330°	59	83	.71
Average		80	99	.81
Near Depression	60°	20	34	.59
	200°	18	30	.60
	310°	15	25	.60
Average		18	30	.60

The growth curves in the latter part of the season were different for the trees in the various sites. These appear to be coincident with the moisture regimes. The growth of the tree near the depression which had a shallow root system was steady while the soil contained a high percent moisture. But the growth abruptly stopped when the soil moisture began to rapidly decrease in the A horizon in early July.

Growth of the more deeply rooted tree on the beech-maple or highest site had its maximum in early June followed by a gradual cessation of growth which continued into July. The soil moisture showed a corresponding gradual reduction to wilting percentage in both A and B horizons.

The growth of the younger tree in the less mature stand continued into August, apparently less affected by the drought conditions. The soil moisture on this site remained well above wilting percentage.

Differences in total radial increase were due more to differences in xylem formation than any other tissue in the stem.

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